MODEL 600M
MILITARY MicroVAX II
MIL-STD-461B EMI TEST REPORT

CODAR
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MILITARY MicroVAX II
MIL-STD-461B EMI TEST REPORT

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TABLE OF CONTENTS

SECTION	PAGE NUMBER
SUMMARY	1
PURPOSE	1
TEST FACILITY	2
MODEL 600M TEST SAMPLE	2
TEST DATA INTERPRETATION	3
EMISSIONS	5
RE02 TEST RESULTS	6
CE03 TEST RESULTS	7
CE01 TEST RESULTS	7
TEMPEST IMPLICATIONS	8

APPENDIX A: TECHNICAL UPDATE & NEW TEST DATA
APPENDIX B: EMI TEST LOG
APPENDIX C: CALIBRATION DATA
APPENDIX D: EQUIVALENT METER READINGS
APPENDIX E: RE02 TEST DATA PLOTS
APPENDIX F: COMPOSITE MIL-STD-461B AND RE02 DATA PLOT
APPENDIX G: CE01 TEST DATA PLOTS
APPENDIX H: CE03 TEST DATA PLOTS
APPENDIX I: COMPOSITE MIL-STD-461B AND CE03 DATA PLOT

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MODEL 600M EMI TEST REPORT

SUMMARY

A production Model 600M MicroVAX II was submitted to Ball Aerospace Corporation for EMI testing and certification to the requirements of MIL-STD-461B, Methods CE03 Part 5 (conducted emissions) and RE02 Part 5 (radiated emissions). The Model 600M passed both test sequences without modification. The 600M also passed CE01 from 3 KHz to 15 KHz.

Additional testing was performed which showed that from 10 KHz to 12 GHz all radiated emissions were below -100 dBm/m when measured at a distance of 1 meter with a 1 KHz receiver bandwidth.

Testing was conducted on a fully configured production Model 600M with a MicroVAX II CPU, 9 Mbytes of memory, two RD53 disks, TK50 tape and two DHV11's. During testing, the system was performing continuous random read/writes to the internal 71 Mbyte disk drive.

The test facility director commented that "The model 600M had the lowest radiated emissions of any piece of equipment they had tested including battery operated space craft packages".

PURPOSE

This document provides information on EMI testing conducted on Codar Technology's Model 600M military MicroVAX II computer system. The primary purpose of the test program was to obtain certification for MIL-STD-461B, Method CE03 Part 5 for conducted emissions and Method RE02 Part 5 for radiated emissions.

MIL-STD-461B provides numerous different acceptable emissions levels depending on the ultimate application of the system. We chose to use Part 5 (shipboard) which is the most difficult to meet.

Additional testing was performed to demonstrate the ability of the Model 600M to satisfy TEMPEST emissions requirements at all frequencies between 10 KHz and 12 GHz. However, this data is subject to interpretation as testing was not performed in a formal NSA recognized test program.

Copies of the actual 600M test data, facility test logs and antenna calibration data are included in this report.

TEST FACILITY

All testing was performed by Ball Brothers Aerospace Corporation in Boulder Colorado. Ball is a major defense contractor with extensive experience and equipment for DOD and NASA EMI testing. A copy of the Ball facilities brochure is include in the appendix of this document.

Testing was conducted on December 11, 1986 using an Eaton Ailtech Series VII Automatic Data Collection System in a fully shielded enclosure. MIL-STD-461B testing was performed using procedures as defined in MIL-STD-462.

The Ailtech test system consists of banks of tunned receivers with programmable sweep rates, simultaneous narrow and broad band detectors and a plotter output. Preliminary measurements were also made using an HP 8568B digital spectrum analyzer. The receiving antennas were calibrated by the Ball Brothers antenna group with all data traceable to NBS.

MODEL 600M TEST SAMPLE

All test were performed on a standard production model 600M system. The selected machine was one of several which had been purchased by Sperry Electronic Warfare for the Navy. It is identified in the test data as "Sperry #2" for convenience.

This system included a KA630-AA MicroVAX II CPU, 9 Mbytes of memory, TK50 tape cartridge and controller, two RD53 71 Mbyte winchester disk drives and controller and two DHV11 four line communication interfaces.

Our goal was to obtain EMI data under worst case conditions. Previous test at CTI with our own EMI test equipment had shown that the disk system was a major source of EMI. Thus, we wrote a VMS program that performed continuous random read/writes of unused portions of the disk. All 461B data was obtained while this program was running.

The tested machine was equipped with what we refer to as the customer developmental rear panel. This panel has cutouts for four standard DEC I/O plates plus one oversize custom plates. The panels are secured to the rear of the machine with bolts. No EMI gaskets are used between any of the I/O panels and the rear panel of the 600M or between any connectors and their mounting surfaces.

NOTE: Production systems are normally equipped with a rear I/O panel which is custom punched to accept specific customer specified connectors with EMI gaskets. Thus, the use of our developmental rear panel represented a worst case test configuration.

DEC DHV11 I/O panels were installed in two of the available openings. The other three were covered with blank plates. The rear panel also contained a 38999 military I/O connector and a DB9 MicroVAX serial console I/O connector. No external cables were connected to any of the connectors. Terminating caps were not used on any of the connectors. Thus, they were free to radiate from their pins.

Prior to the test, we identified the following five possible sources of emissions:

1. Lack of gaskets around the rear panel I/O plates.
2. Lack of gaskets around the actual I/O connectors.
3. Direct radiation from the unterminated I/O connectors.
4. Emissions thru the front panel control switches.
5. Emissions thru the 16 digit front panel display.

Before commencing the formal 461B test, each of these areas were individually tested using a "sniffer probe" and HP spectrum analyzer. No emissions were detected using this technique.

TEST DATA INTERPRETATION

Copies of all recorded test data are included in this report. This data consists of three distinct sets;

1. RE02 radiated emissions (15 KHz - 10 GHz).
2. CE03 conducted emissions (15 KHz - 50 MHz).
3. CE01 conducted emissions (30 Hz - 15 KHz).

For clarity, we have renumbered each page of test data in the lower right-hand corner. This is to prevent confusion over page numbers within each test sequence.

The RE02 test data covers the required frequency range per MIL-STD-461B Part 5 of 15 KHz to 10 GHz. However, we extended the total range from 10 KHz to 12 GHz.

All data plots have been identified with the MIL-STD-461B Part 5 limits for narrow and broad band emissions, as appropriate.

The majority of the RE02 and CE03 test data consists of nothing but a straight line which represents the noise floor of the measuring system. Ball refers to this in the RE02 plots as "MDS" or minimum detectable signal. What little emissions were detected appear as narrow spikes proceeding up several dB from the system noise floor.

The MIL-STD-461B test sequences call for a change in receiver bandwidths at certain frequencies. This explains the apparent change in dynamic range which shows up in the data. As an example, the RE02 narrow band test changes from a 1 KHz to a 100KHz bandwidth at 30 MHz. The increased bandwidth results in a higher instrumentation system noise floor above 30 MHz.

In some cases there was not enough dynamic range on the plots to show both the measured data and the MIL-STD limit. This was handled by using an "offset" on the plots. As an example, look at the RE02 broad band plot from 800 to 1000 MHz. Our "emissions" appear to be 20 dB under the broad band limit. However, the broad band curve is actually plotted with a 20 dB offset as indicated in the "SPEC. LIMIT" box. We are really 40 dB under the limit.

This also shows up in the CE03 data. In the .01 to .25 MHz plot you can see a sudden offset in the plot which indicates the point at which 40 dB of receiver gain was added (or attenuation removed) due to the extremely low level of our conducted emissions. This is documented in the "ACTUAL" box. As an example, the 4 to 8 MHz plot shows our conducted emissions about 20 dB below the narrow band requirement. In reality, we are really 60 dB below the requirement as indicated by the "-40" in the ACTUAL box.

Changes in system gain are also indicated by the presence of two different values in the ACTUAL box. In the above example this is shown as 0/-40 in the CE03 .01 - .25 MHz plot.

The CE01 and CE03 plots show a lighter trace which is offset slightly in frequency from the darker trace. The darker trace represents the "peak" detected output from the receiver. The lighter trace (red in the original) is the field intensity or average detected output.

The difference between the two in amplitude helps determine if the emission is narrow or broad band. If the difference is 6 dB or less at a given frequency, the emission is considered narrow band.

These procedures are standard in EMI testing and will be immediately recognized by many readers. For those without extensive test experience, just remember that many of the plots have been offset or compressed in dynamic range to simplify the visual presentation.

Appendix F shows the RE02 data on a single log plot along with the MIL-STD-461B limits. Appendix I presents the CE03 data in a similar format.

EMISSIONS

There are four specific types of emissions which were encountered in EMI testing on the 600M. These are;

1. AC power line conducted 60 Hz harmonics.
2. AC power line switching power supply noise.
3. Radiated computer generated emissions.
4. Bogus signals not generated by the 600M computer.

The 60 Hz harmonics are very evident in the CE01 test data. These emissions are due to the input capacitor charging in the switching power supply. When the rectified AC line voltage reaches the level of residual voltage on the capacitor, the rectifier diode forward conducts into the capacitor which looks like a very low impedance.

This in turn causes a high current surge which basically converts the AC sine wave input into a modified square wave by clipping the top off the AC sine wave. The result is generation of energy at odd harmonics of 60 Hz with a (sinx)/x distribution.

The 600M's line filter functions as a 2.8 KHz low pass filter. As shown in the data, rapid attenuation of the 60 Hz harmonics begins at about 3 KHz. CE01 is in fact satisfied at frequencies higher than 3 KHz. The worst case problem occurs at 180 Hz where the conducted emissions exceed CE01 by about 18 dB.

CE01 is not normally a system requirement and was not a 600M design goal. In general, it is impossible to meet with a switching power supply without using either three phase power or a large power factor correction inductor. We ran the CE01 sequence primarily because it was a simple extension to CE03. It also provided verification of previous 461B testing which had been performed on the line filter.

The second type of conducted emission is due to the actual switching of the power supply. This emission shows up as two narrow lines at 41 and 43 KHz, one for the +5 supply and one for the +12 supply. These emissions are about 43 dBuA below the CE03 limit.

The third type is radiated emissions due to the 600M itself. These emissions are caused by internal digital signals with fast rise and fall times. Examples can be seen in the RE02 data at 16 and 22 MHz. Depending on information content, these emissions are classified as either "BLACK" or "RED".

The fourth class of emissions are spurious which show up in the measurements but are not generated by the 600M. These signals are easy to identify as they will persist when the computer is turned off. Examples can be seen in the RE02 data at 189 MHz and 1.4 GHz.

RE02 TEST RESULTS

RE02 Part 5 covers radiated electric field emissions from 15 KHz to 10 GHz. We conducted our test over an extended range of 10 KHz to 12 GHz. Above 30 MHz, the test are conducted with both vertical and horizontal polarization. The receiving antenna is located 1 meter from the computer during testing (near field). The complete test procedure is defined in MIL-STD-462, page 61.

All emissions were considerably below MIL-STD-461B RE02 Part 5 requirements from 10 KHz to 12 GHz. Basically we were measuring the noise floor of the Ailtech receiver system. With a 1 KHz bandwidth, this worked out to be about -113 dBm/m or -6 dBuV/m. The worst case narrowband emission exceeded the system noise floor by about 6 dB at 22 MHz. The worst case broadband emission was about 12 dB above the noise at 36 MHz with vertical polarization.

We attribute the 600M's excellent EMI suppression to the following:

1. The use of tin/nickel/copper plating over aluminum.
2. Substantial use of machined mechanical components with integral EMI gaskets.
3. A high performance multi-pole custom AC line filter.
4. Use of a fully sealed AC input compartment.
5. Careful design of the 600M's AC & DC ground circuitry.

CE03 TEST RESULTS

CE03 Part 5 covers AC line conducted emissions from 15 KHz to 50 MHz, both narrow and broadband. The test setup is the same as used for CE01. Both sides of the AC power line are measured. We extended our data set from the required 50 MHz to 100 MHz.

Starting at 15 KHz we are 28 dBua below the narrowband limit. From 150 KHz to 100 MHz all conducted emissions are below the measurement system noise floor. This corresponds to about 60 dBua below the narrowband limit depending on receiver bandwidth. As shown in the plots, the Ailtech receiver is essentially drawing a straight line out to 100 MHz. The same holds true for the broadband measurements.

Of particular interest is the fact that no conducted emissions due to the MicroVAX, internal logic or disk drive were detected. This level of suppression can only be obtained thru the use of a large multi-pole line filter and extensive shielding (the 600M's line filter is 10.5" x 3.5" x 2").

CTI has previously run CE01 and CE03 test on the system power supplies. During these test, the supplies were loaded with high power resistors. Data obtained using the resistors looks almost identical to the new data obtained with the full computer system. This provides additional confirmation that very little computer generated energy is escaping thru the filter.

CE01 TEST RESULTS

We have included the CE01 test for information purposes only. Its primary function is to demonstrate the effectiveness of the 600M's AC line filter at low frequencies.

This test is conducted using a current probe on first one side of the AC line cord and then the other side which results in two almost identical sets of data. CE01 Part 5 is conducted from 30 Hz to 15 KHz. The experimental setup is shown in MIL-STD-462, page 14.

The 600M shows high 60 Hz odd harmonics as expected due to the power supply input capacitor. At 180 Hz we exceed the requirement by about 18 dB. At 3 KHz we meet the requirement and continue to meet it out to 15 KHz. At 15 KHz we are actually 28 dBua below the narrowband limit, a tribute to the line filter.

TEMPEST IMPLICATIONS

We realize that many customers have TEMPEST related requirements. At this time, the 600M is not on the PPL. However, the 600M's almost total lack of emissions makes it a prime candidate for TEMPEST programs with minimal additional testing.

In order for an emission to carry information it must contain some type of modulation, either amplitude, phase or frequency. Thus, a discrete single frequency emission, such as from an internal computer oscillator, indicates only the presence of the computer but conveys no information such as an internal key. Switching power supply noise and 60 Hz harmonic generation fall into the same category - present but not usually decipherable information.

During our RE02 testing we attempted to classify the few emissions that were detectable as either RED or BLACK. This was accomplished using two techniques:

1. Halting the computer and checking to see if the emission changed. If it did, it would be considered code dependent and possibly a RED emission. Otherwise, it was considered BLACK. No RED emissions were positively identified.

2. We also listened to these emissions using the detected output of the receiver with headphones and a narrow receiver bandwidth. Again, no modulation was detected.

This was by no means an exhaustive search to 5100 standards. However, the results were very encouraging and led to the following conclusions:

1. The standard 600M is extremely quiet at 1 meter.

2. At 2 or 4 meters the 600M should be undetectable (an additional 6 or 12 dB of suppression assuming far field propagation).

3. The 600M was tested worse case due to the rear panel. A production rear panel with EMI gaskets will provide even greater suppression.

4. A shielded display window does not appear to be necessary.

A complete 5100 certification will require a more detailed investigation of each emission in conjunction with more module specific VMS testing software.

Additional testing and certification can be arranged on either the 600M or 600MT to meet your specific program requirements. In conjunction with Ball Aerospace, we can also provide RE02 emission testing of complete cabled systems with CRTs, printers etc.

APPENDIX A:

TECHNICAL UPDATE & NEW TEST DATA

There are no technical additions or corrections to this test report at this time.

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APPENDIX B:

EMI TEST LOG

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EMI TEST LOG

Sheet 1 of 2

(Date)	(Model)	(Serial No.)
11 Dec 1986	Sperry #2 COVAR Tech Model 600M	Not Installed
(Test Spec.)	**(Location)**	**(Test Conductor)**
MIL-STD 461B	BASD Boulder Co	W. Moffett

Date	Time	Log Entry	Remarks
12/11/86	0800	Customers arrived with Unit for test.	Mike Evans Carroll Campbell
		Set the Unit up on the ground plane for Conducted Emissions. Bonded Unit on rear ground lug to the ground plane. Set 10uf feedthru caps on power line with 2 meters of power line	x unwrapped 1 meter of power line serpentine
	0950	Measured bond to gnd plane ~ 1.0 milliohms	
	0930	Start CE01 Plot 1 Supply Line	Disk Exercizer
	0940	START CE01 on Return Line.	
		NOTE: The wideband conducted emissions, in the CE01 range, are 90 dBuA/20kHz for Both Power Lines.	
	1020	START CE03. A narrowband and broadband plot will be generated for each Power Line.	

CONCURRENCE:	DATE:
Q.A.	
DCAS	
DATA REVIEWED BY WLM	12/12/86

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APPENDIX C:

CALIBRATION DATA

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Plot Analysis of Ailtech Series VII Output

Conducted and radiated emission measurements were made utilizing the Eaton Ailtech Series VII Automatic Data Collection System. This system utilizes a simultaneous dual plot of the peak and average signal level for detection. The operating analysis of the recorded data for the determination of a signal to be narrowband or broadband shall be: if the amplitude difference is less than 6 dB between peak and average, the signal level is narrowband; if the amplitude is greater than or equal to 6 dB, then the signal level is broadband. In both cases for frequency and level comparison to the specification limit, the recorded peak level shall be used. To aid the interpretation of the plot, the following points of information are noted:

- The bands or blocks have the frequency calibrated on their X-axis and the receiver meter level on their Y-axis.

- The attenuator setting blocks, labeled "specification limit" and "actual", display the receiver front end attenuation in dB above and below 0 dBuV.

- The attenuator block, labeled "specification limit", is the adjusted level of the limit to an arbitrary equivalent attenuation setting to allow adjustments to on-scale indications of the limit.

- The attenuator block, labeled "actual", is the setting used for the recording of emissions, which may differ either to attenuate higher signals or to increase sensitivity for low signals.

- The recorded levels will always display the peak level above the average level, except for a CW (0% modulation) signal where they are equal.

- Recorded signals for analysis must first be recognized as narrowband or broadband, and only then compared to the appropriate limit using the peak level and difference between actual and specification attenuation blocks.

- The recorded average signal is offset in frequency to the left by 1/8 inch and shall not be used for frequency determination.

Further understanding of the data collection system plots may be gained by reading the test procedure paragraph on "Identification of Broadband and Narrowband Emissions", and a review of the "Equivalent Meter Readings" correction graphs.

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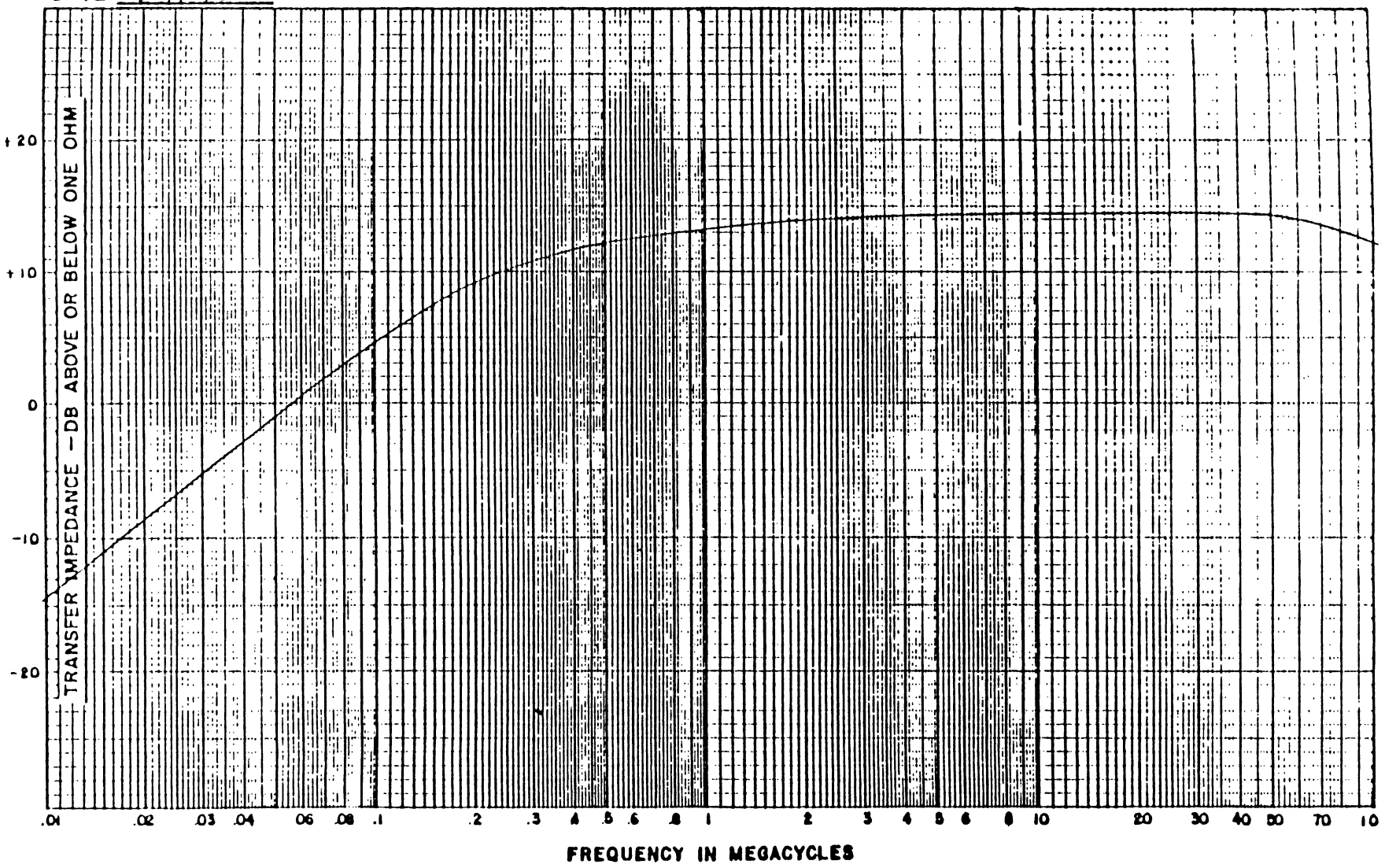
CALIBRATING ENGINEER: R. GAONA

DATE: 2-17-69

CURRENT PROBE 91550-1

SERIAL NO. BF532

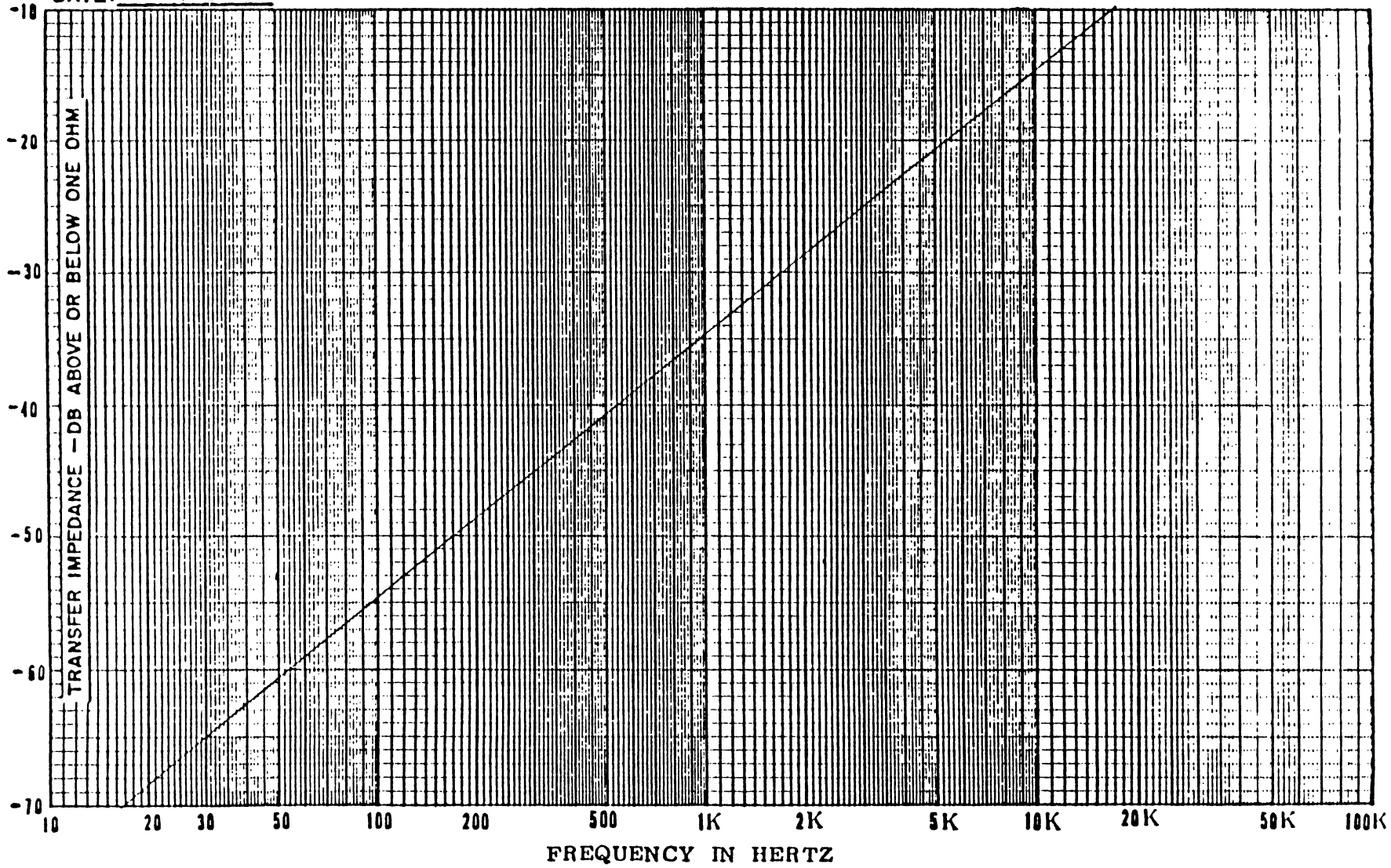


CALIBRATING ENGINEER: R. GAONA

DATE: 2-17-69

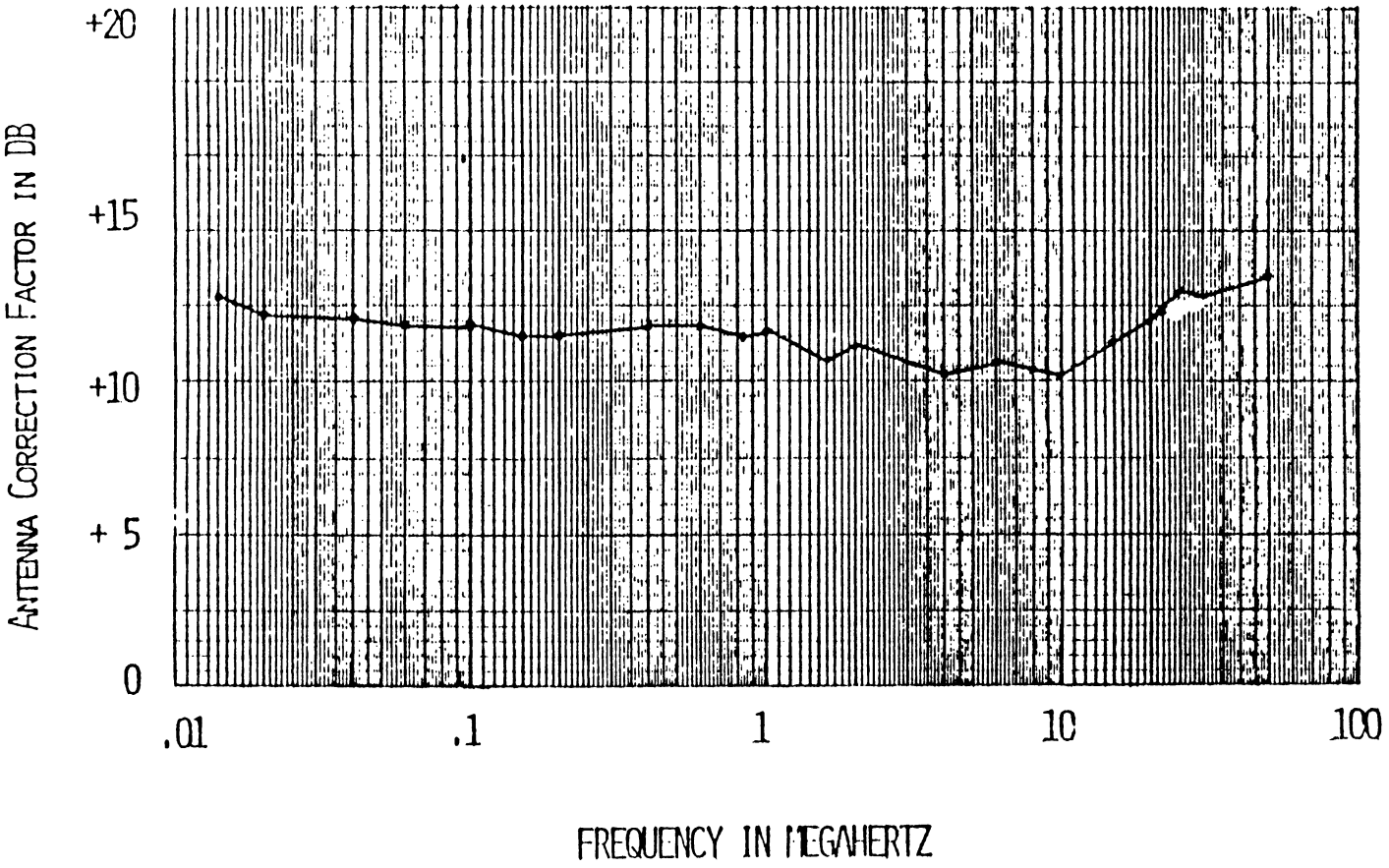
CURRENT PROBE 91550-1

SERIAL NO. BF532



ANTENNA CORRECTION FACTOR

EMCO MODEL 3301 S/N 2049

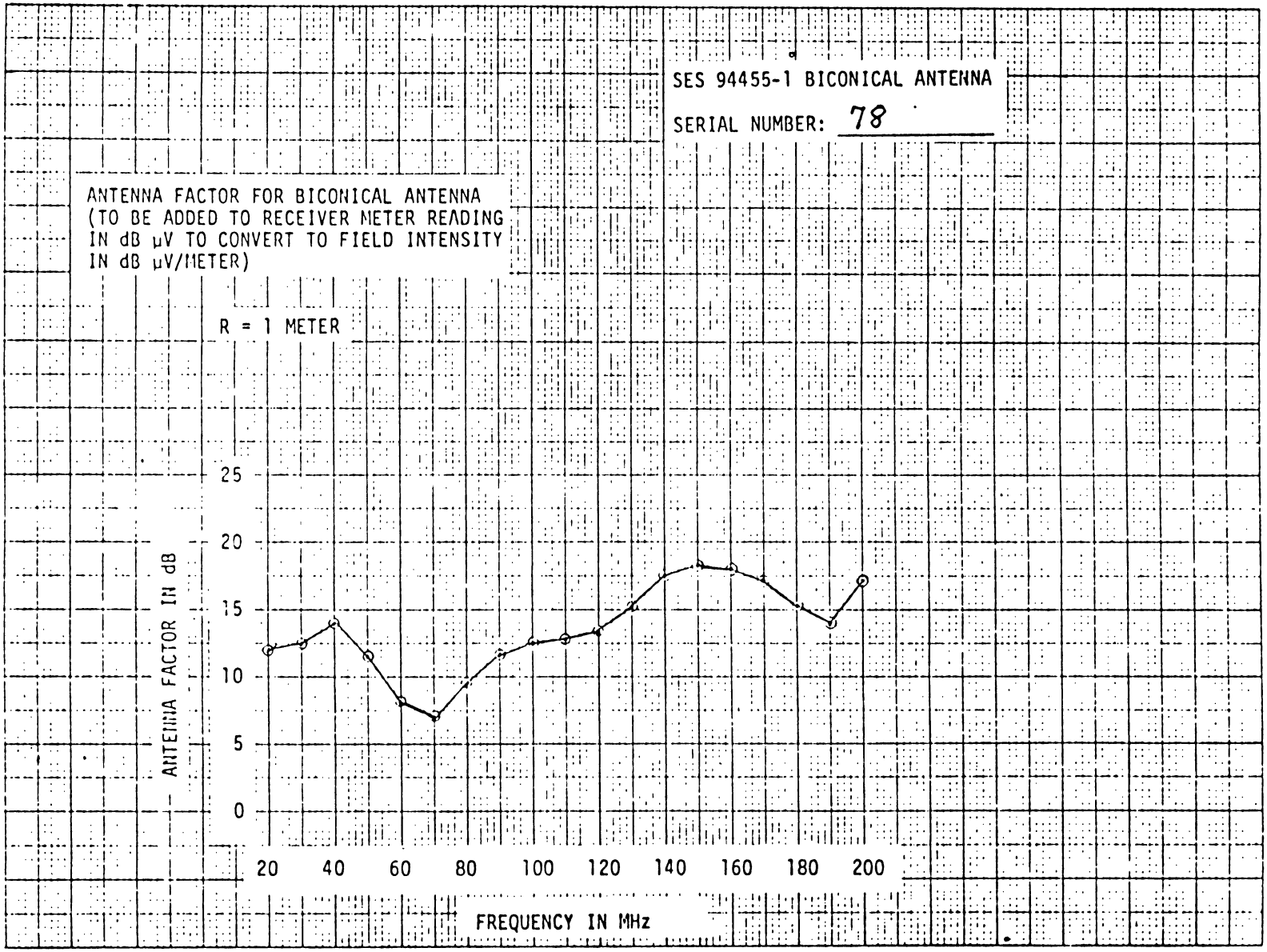


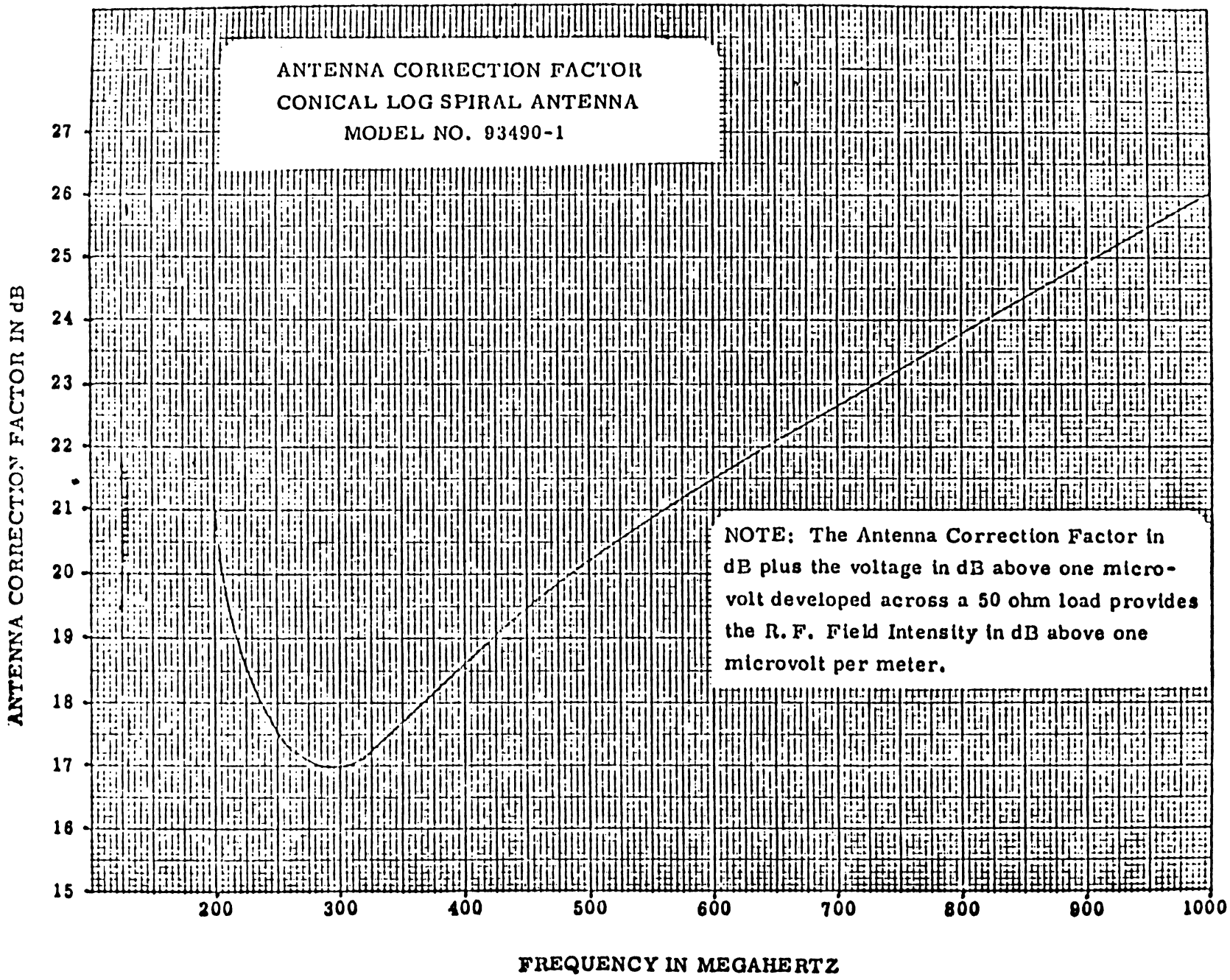
SES 94455-1 BICONICAL ANTENNA

SERIAL NUMBER: 78

ANTENNA FACTOR FOR BICONICAL ANTENNA
(TO BE ADDED TO RECEIVER METER READING
IN dB μV TO CONVERT TO FIELD INTENSITY
IN dB μV/METER)

R = 1 METER




ANTENNA CORRECTION FACTOR
CONICAL LOG SPIRAL ANTENNA
MODEL NO. 93490-1
NOTE: The Antenna Correction Factor in dB plus the voltage in dB above one microvolt developed across a 50 ohm load provides the R. F. Field Intensity in dB above one microvolt per meter.
ANTENNA CORRECTION FACTOR IN dB
27
26
25
24
23
22
21
20
19
18
17
16
15
200
300
400
500
600
700
800
900
1000
FREQUENCY IN MEGAHERTZ

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ACTUAL GAIN AND ANTENNA FACTOR

EMCO Model 3115 Double Ridged Guide Antenna

Serial No. 2046

Frequency (GHz)	Numeric Gain	Antenna Factor* (dB)
1	4.189	24.0
1.5	6.283	25.8
2	6.655	28.0
2.5	8.318	29.0
3	7.929	30.8
4	8.400	33.0
5	10.497	34.0
6	12.596	34.8
7	13.097	36.0
8	13.341	37.1
9	13.376	38.1
10	13.246	39.0
11	18.343	38.4
12	17.835	39.3
12.4	20.678	39.0
13	21.679	39.2
14	18.545	40.4
15	22.294	40.3
16	37.688	38.6
17	31.808	39.8
18	33.679	40.1

*Specification Compliance Testing Antenna Factor (1 Meter spacing to convert receiver reading (dBuV) to field intensity (dBuV/M).

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APPENDIX D:

EQUIVALENT METER READINGS

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EQUIVALENT METER READINGS

TEST METHOD RE02 NB SPECIFICATION 46 CFR

E.M.R. = Specification Limit (-) BW Factor (+) Pick-up Device (-) Cable Loss

Freq. MHz	Spec. Limit dBuV/m	B.W. (dB) Pre Amp	Cable (dB)	Device (dB)	E.M.R.
			12' RG-214	EMCO 3301	
0.014	35	0 27	0	13	49
0.15	30	0	0	12	45
0.25	21	0	0	12	44
0.4	28	0	0	12	43
0.5	[illegible]	0	0	12	42.5
0.8	27	0	0	12	42
1.0	26	0	0	12	41
1.6	25.5	0	0	11	41.5
2.0	25	0	0	12	40
3.0	24	0	0	11	40
4.0	[illegible]	0	0	10	40.5
6.0	23	0	0	11	39
8.0	22	0	0	10	39
12.0	21.5	0	0	11	37.5
16.0	21	0	0	12	36
24.0	20	0	0	12	35
25.0	20	0	0	12	35
30.0	[illegible]	0	0	13	35.5
32.0	22	0 V	0	13	36

EQUIVALENT METER READINGS

TEST METHOD 11/2 SPECIFICATION 11/2/6 No. 4 2

E.M.R. = Specification Limit (-) BW Factor (+) Pick-up Device (-) Cable Loss

Freq. MHz	Spec. Limit	B.W. (dB) 120 KHz	Cable (dB)	Device (dB)	E.M.R.
		27		BICONACAL 94455-1	
30.0	21.5	0	0	13	35.5
40.0	23	0	0	14	36
55.0	25.5	0	0	10	42.5
60.0	2[illegible]	0	0	8	45
80.0	[illegible]	0	0	9	46
100.0	29.5	0	0	13	43.5
110.0	30	0	0	13	44
150.0	32	0	0	18	41
190.0	34	0	0	16	45
200.0	34	0	0	17	44
				LOG SPIRAL 3101	
200.0	34	0	0	21	40
250.0	35	0	0	18	44
290.0	37	0	0	17	47
300.0	37	0	0	17	47
360.0	35	0	0	18	47
420.0	3[illegible]	0	0	19	47
440.0	39.5	0	0	19	47.5
520.0	40	0 V	0	20	47

EQUIVALENT METER READINGS

TEST METHOD NB SPECIFICATION 461B Part 7

E.M.R. = Specification Limit (-) BW Factor (+) Pick-up Device (-) Cable Loss

Freq. MHz	Spec. Limit	B.W. (dB)	Cable (dB)	Device (dB)	E.M.R.
600.0	41	0	0	22	46
720.0	42	0	0	23	46
800.0	43	0	0	24	46
920.0	44	0	0	25	46
1000.0	45	0	1	27	44
			6' RG-214	EMCO 3115	
1000.0	45	0	0	24	21
2000.0	49	0	1	28	20
3000.0	52	0	1	31	20
4000.0	54	0	1	33	20
5000.0	55	0	2	34	19
6000.0	56,5	0	2	35	19,5
7000.0	59	0	2	36	19,5
8000.0	60	0	2	38	18,5
9000.0	57	0	3	38	18
10000.0	62	0	3	39	18
~~18000.0~~		~~0~~	~~5~~	~~41~~	

EQUIVALENT METER READINGS

TEST METHOD RE02 BR SPECIFICATION [illegible]

E.M.R. = Specification Limit (-) BW Factor (+) Pick-up Device (-) Cable Loss

Freq. MHz	Spec. Limit	B.W. (dB)	Cable (dB) Pre Amp	Device (dB)	E.M.R.
			27/12' RG-214	EMCO 3301	
0.014	100	40	0	13	74
0.15	89	40	0	12	64
0.25	[illegible]	40	0	12	61.5
0.4	84	40	0	12	59
0.5	83	40	0	12	58
0.8	82	40	0	12	57
1.0	[illegible]	40	0	12	55
1.6	77.5	40	0	11	55.5
2.0	76.5	40	0	12	51.5
3.0	[illegible]	26 40	0	11	[illegible]
4.0	[illegible]	26	0	10	50.5
6.0	[illegible]	26	0	11	47.5
8.0	[illegible]	26	0	10	47
12.0	[illegible]	26	0	11	44
16.0	[illegible]	26	0	12	42
24.0	[illegible]	26	0	12	40
25.0	[illegible]	26	0	12	[illegible]
30.0	64	26	0	13	37
32.0	[illegible]	26	0	13	[illegible]

EQUIVALENT METER READINGS

TEST METHOD RED, [illegible] SPECIFICATION [illegible]

E.M.R. = Specification Limit (-) BW Factor (+) Pick-up Device (-) Cable Loss

Freq. MHz	Spec. Limit	B.W. (dB)	Cable (dB)	Device (dB)	E.M.R.
			Pre AMP 27	BICONACAL 94455-1	
30.0	64	0	0	13	78
40.0	62.5	0	0	14	75.5
55.0	61	0	0	10	78
60.0	[illegible]	0	0	8	79.5
80.0	[illegible]	0	0	9	77
100.0	[illegible]	0	0	13	72
110.0	58	0	0	13	72
150.0	56	0	0	18	65
190.0	55	0	0	16	66
200.0	55	0	0	17	65
				LOG SPIRAL 3101	
200.0	[illegible]	0	0	21	61
250.0	57	0	0	18	66
290.0	58.5	0	0	17	65.5
300.0	58.5	0	0	17	68.5
360.0	60	0	0	18	71
420.0	62	0	0	19	70
440.0	62	0	0	19	70
520.0	64	0	0	20	71

EQUIVALENT METER READINGS

TEST METHOD RED ~ B's SPECIFICATION 461B Pt. 5

E.M.R. = Specification Limit (-) BW Factor (+) Pick-up Device (-) Cable Loss

Freq. MHz	Spec. Limit	B.W. (dB)	Cable (dB)	Device (dB)	E.M.R.
600.0	65	0	0	22	70
720.0	67	0	0	23	71
800.0	68	0	0	24	71
920.0	69	0	0	25	71
1000.0	70	0	1	27	69
			6' RG-214	EMCO 3115	
1000.0		0	0	24	
2000.0		0	1	28	
3000.0		0	1	31	
4000.0		0	1	33	
5000.0		0	2	34	
6000.0		0	2	35	
7000.0		0	2	36	
8000.0		0	2	38	
9000.0		0	3	38	
10000.0		0	3	39	
18000.0		0	5	41	

APPENDIX E:

RE02 TEST DATA PLOTS

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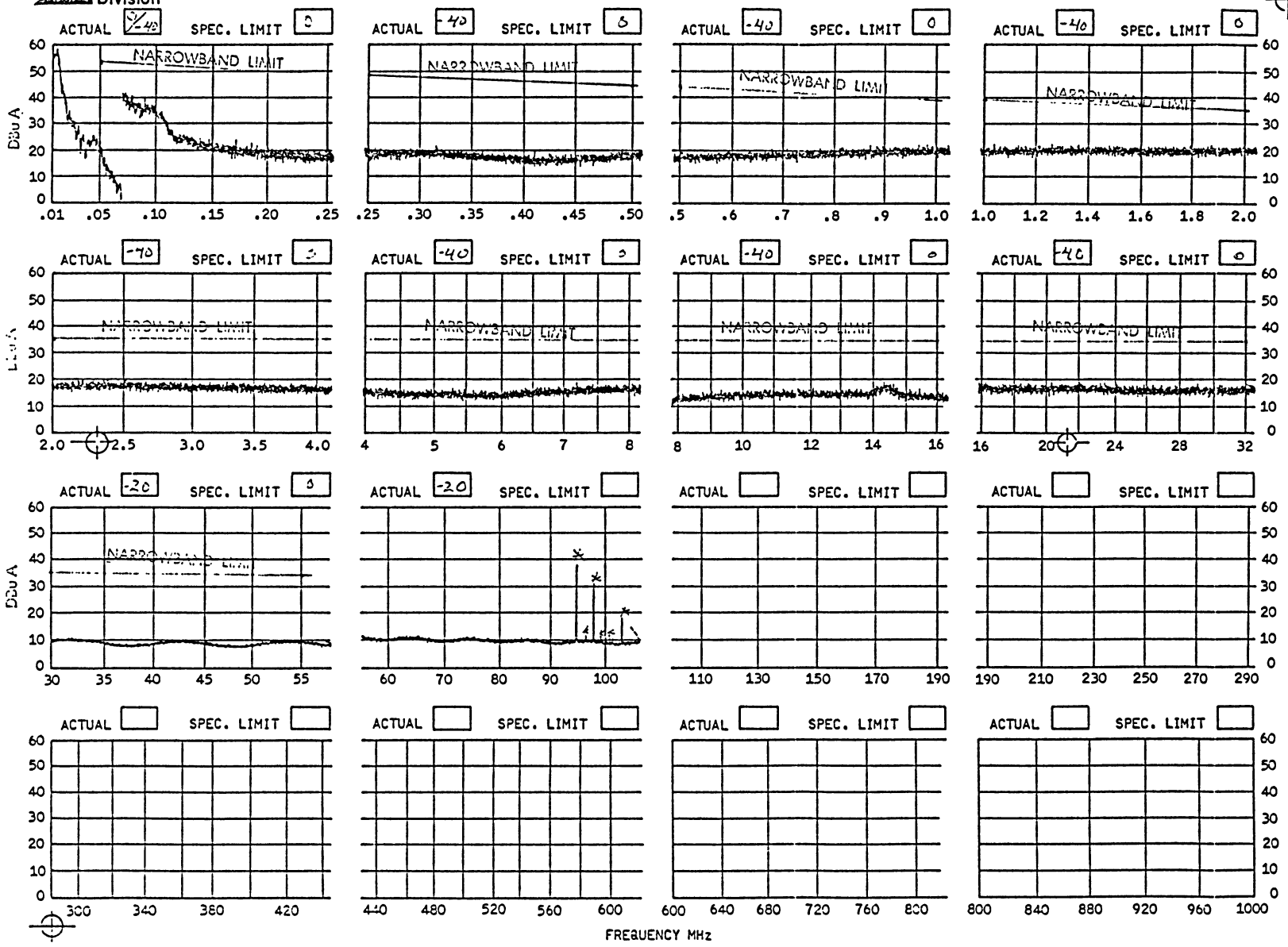
Aerospace Systems Division

ATTENUATOR SETTINGS

PAGE NO. 5



TEST ORDER NO. _____

CUSTOMER CODAR Tech

TEST SAMPLE 1000 M

PART NO. — Spare #2

SERIAL NO. —

DATE 12/11/86

SPECIFICATION MIL-STD-461B

NOTICE Part 5 Fig 5-5

TEST METHOD

CONDUCTED	X
RADIATED	
BROADBAND	
NARROWBAND	X
TRANSIENT	

TEST MODE Supply Power Line CE03

CONDUCTED BY R Cresswell

WITNESSED BY _____

TEST EQUIPMENT Altech Series 7

NM17/27 Bw = 1 kHz

NM37/57 Bw = 10 kHz

CURRENT PROBE BE-532

ANTENNA —

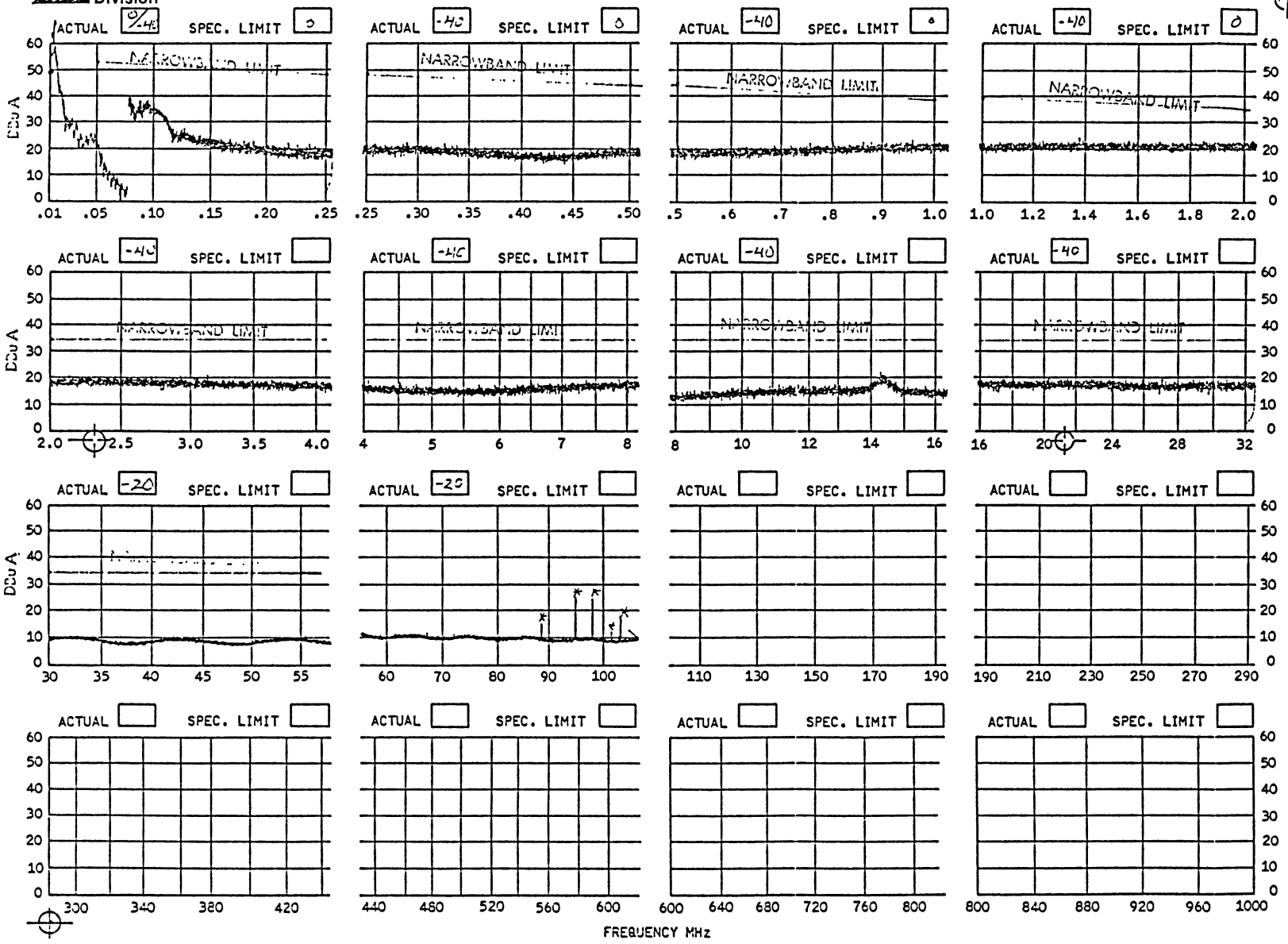
BANDWIDTH See Above

SCAN SPEED 210 s/scan

REMARKS * FM radio

Ball Aerospace Systems Division

ATTENUATOR SETTINGS



TEST ORDER NO. _____

CUSTOMER CODAR Tech.

TEST SAMPLE 600 M

PART NO. - Sperry #2

SERIAL NO. -

DATE 12/11/86

SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	X
RADIATED	
BROADBAND	
NARROWBAND	X
TRANSIENT	

TEST MODE Return Power Line CE03

CONDUCTED BY R. Cresswell

WITNESSED BY _____

TEST EQUIPMENT A.Itech Series 7

NM17/27 Bw = 1kHz

NM37/57 Bw = 10 kHz

CURRENT PROBE BF-532

ANTENNA —

BANDWIDTH See Above

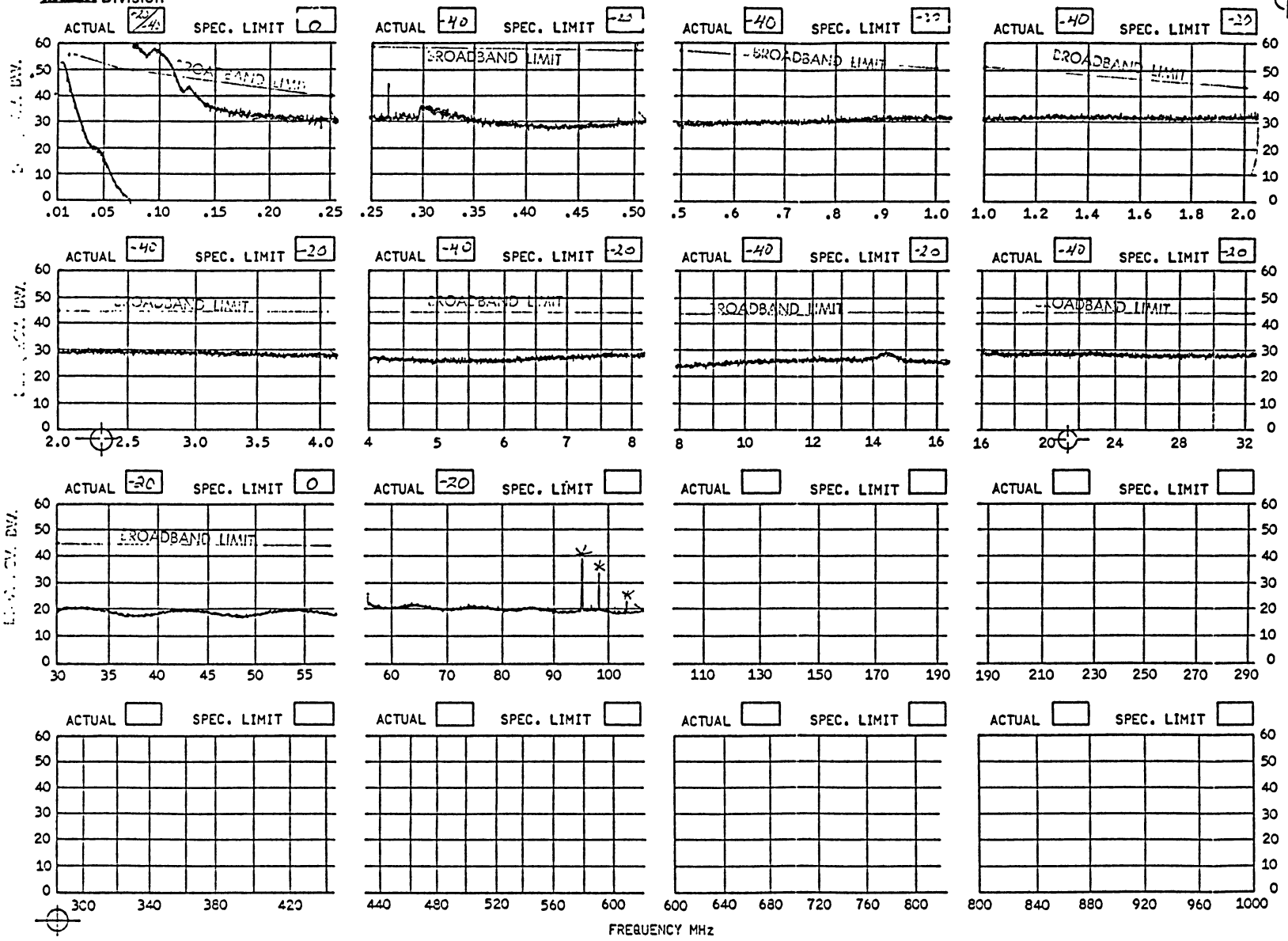
SCAN SPEED 210 s/scan

REMARKS * FM Radio

Bell Aerospace Systems Division

ATTENUATOR SETTINGS

PAGE NO. 7



TEST ORDER NO. _____

CUSTOMER Capps Tech

TEST SAMPLE Delta M

PART NO. Spacey #2

SERIAL NO. -

DATE 12/11/96

SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	X
RADIATED	
BROADBAND	X
NARROWBAND	
TRANSIENT	

TEST MODE Supply Power Line CE03

CONDUCTED BY B. Cresswell

WITNESSED BY _____

TEST EQUIPMENT Ailtech Series 7

NM17/27 Bw = 10kHz

NM37/57 Bw = 100kHz

CURRENT PROBE BE-532

ANTENNA -

BANDWIDTH See Above

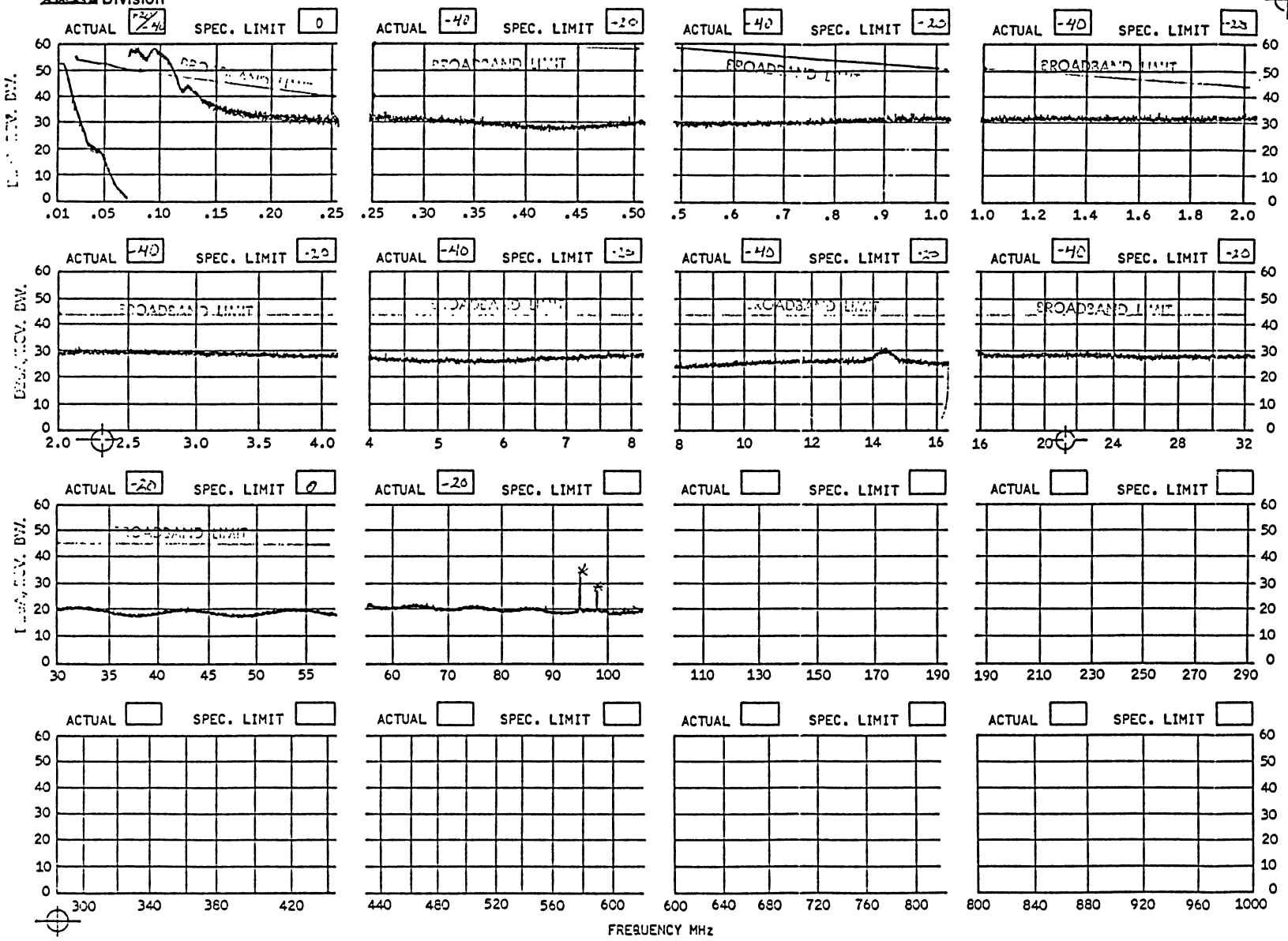
SCAN SPEED 2/10 s/scan

REMARKS * FM Radio

Ball Aerospace Systems Division

ATTENUATOR SETTINGS

PAGE NO. 8



TEST ORDER NO.

CUSTOMER CODAR

TEST SAMPLE 600 M

PART NO. Sperry #2

SERIAL NO. -

DATE 12/11/81

SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	X
RADIATED	
BROADBAND	X
NARROWBAND	
TRANSIENT	

TEST MODE Return Power Line CE03

CONDUCTED BY R Cresswell

WITNESSED BY

TEST EQUIPMENT Ailtech Series 7

NM17/27 Bw = 10kHz

NM37/57 Bw = 100kHz

CURRENT PROBE RE-532

ANTENNA —

BANDWIDTH See Above.

SCAN SPEED 210 s/scan

REMARKS * FM Radio

APPENDIX F:

COMPOSITE MIL-STD-461B AND RE02 DATA PLOT

(To be supplied)

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APPENDIX G:

CE01 TEST DATA PLOTS

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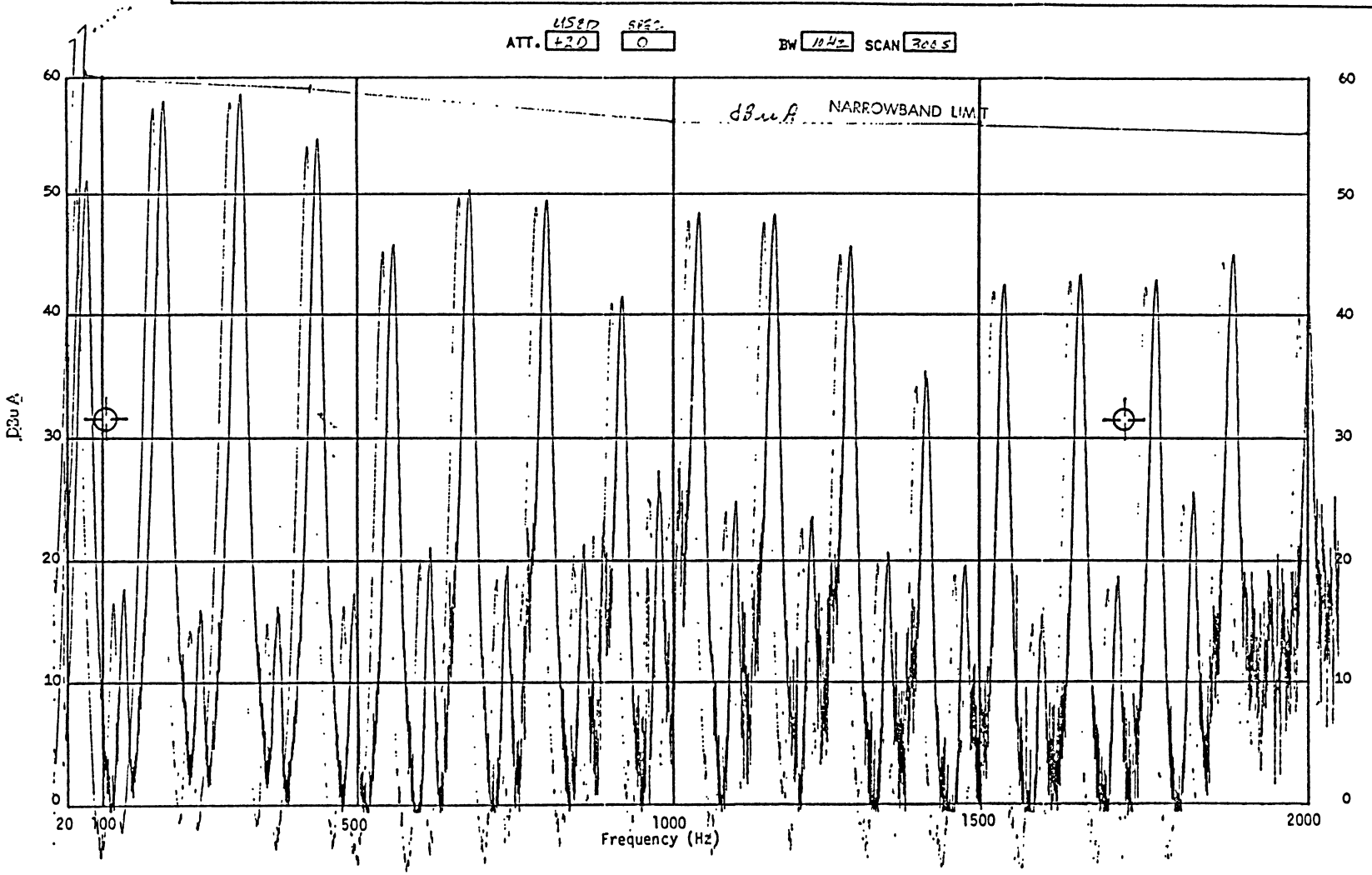
Ball Aerospace Systems Division

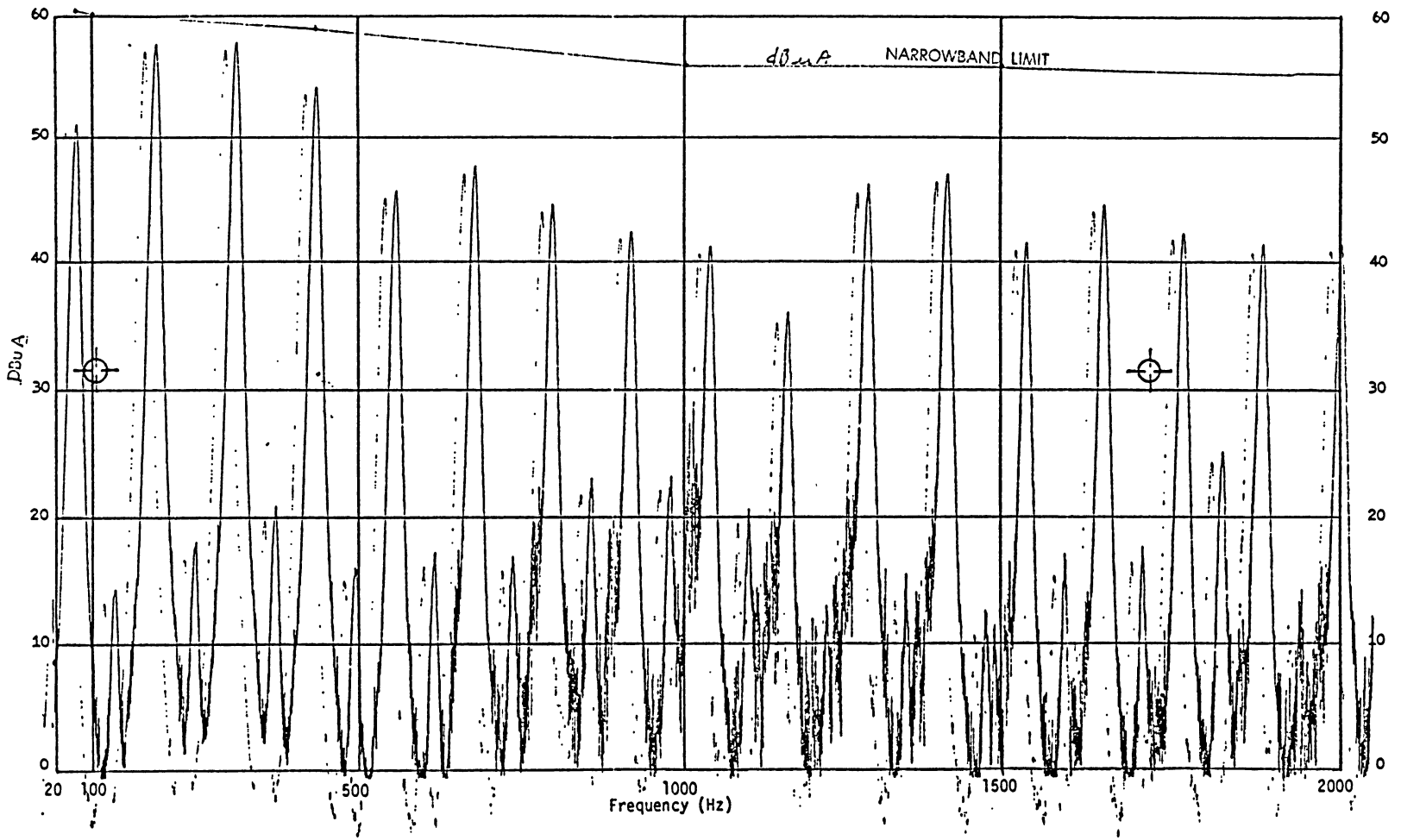
TEST SAMPLE: Spacy #2 600 M	TYPE OF TEST: CE01	SHEET NO.: 1
SPECIFICATION: MIL-STD-461B NOTICE: Part 4 Fig 5-2	TEST POSITION: Supply Power line	DATE: 12/16/76
OPERATING CONDITIONS:	OPERATOR: R. Cressuelli	CAL. DATE: 5/10/82
REMARKS:		



Aerospace Systems Division

TEST SAMPLE: Sperry #7 (610 M	TYPE OF TEST: CE01	SHEET NO.: 2
SPECIFICATION: MIL-STD-461A NOTICE: Part 5	TEST POSITION: Return Power Line	DATE: 12/11/56
OPERATING CONDITIONS:	OPERATOR: R. Crosswell	CAL. DATE: 5/13/57
REMARKS:		

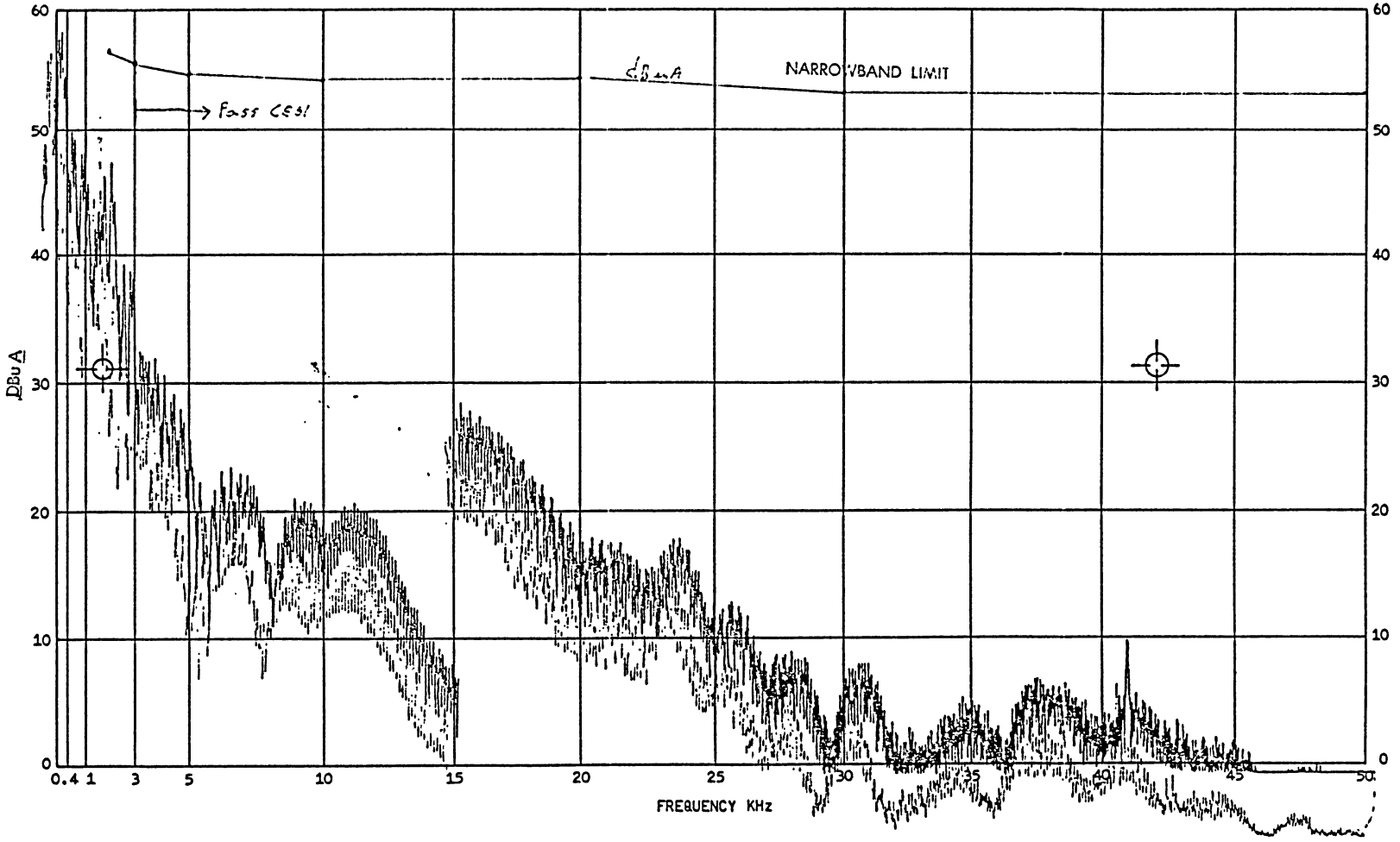
ATT. USD 120 | 0 | BW 10HZ | SCAN 30S



Aerospace Systems Division

TEST SAMPLE: Speary #2 1650 M	TYPE OF TEST: CE01	SHEET NO.: 3
SPECIFICATION: MIL-STD-461B NOTICE: Part 5	TEST POSITION: Supply Power Line	DATE: 12/11/80
OPERATING CONDITIONS:	OPERATOR: R Crescenzi	CAL. DATE: 5/10/79
REMARKS: Wide band Measurement = 90 dB		

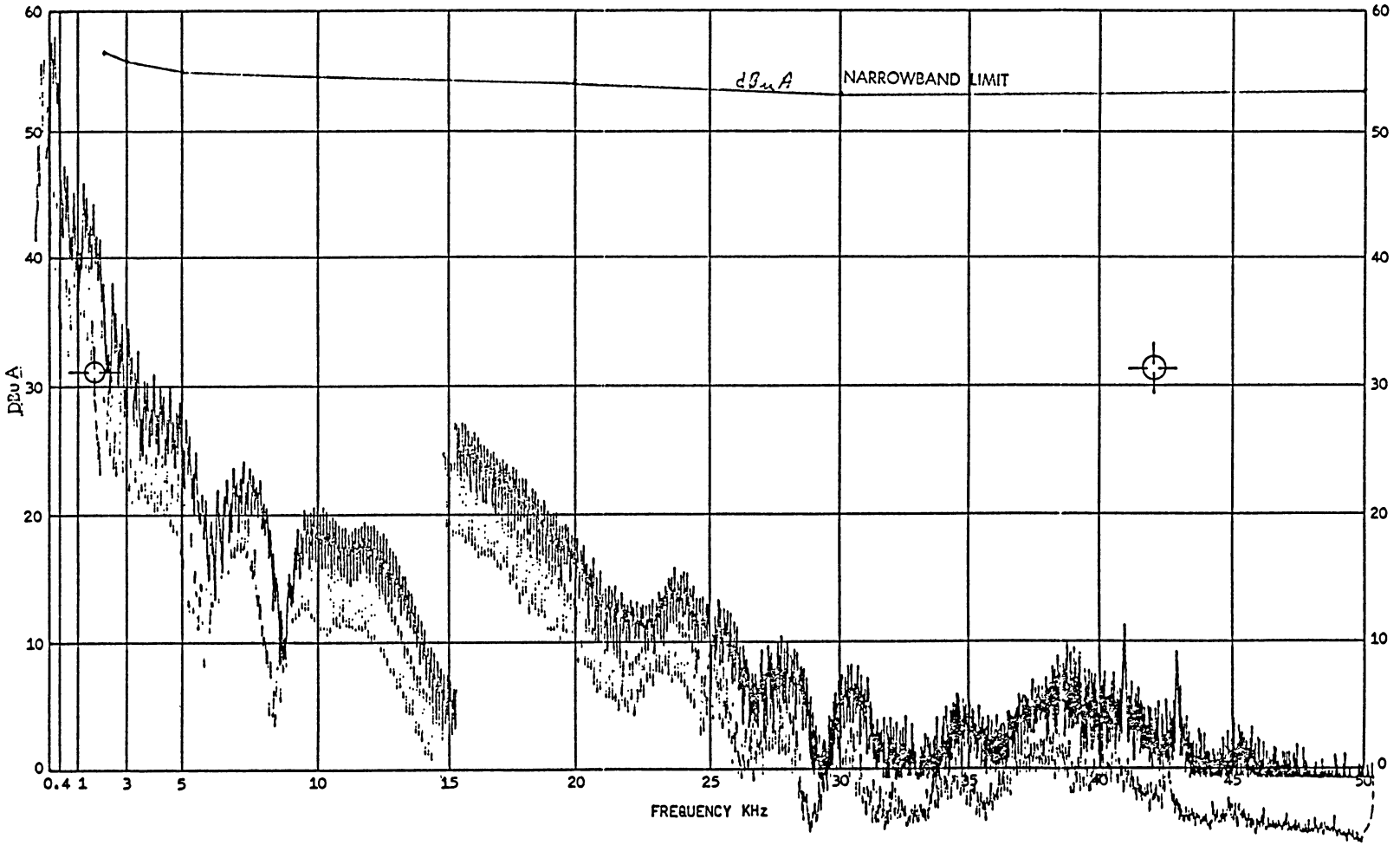
ATT. USED 20/0 | 0 | BW 100Hz | SCAN 3ms



Ball Aerospace Systems Division

TEST SAMPLE: Speery #2 600 M	TYPE OF TEST: CE01	SHEET NO.: 4
SPECIFICATION: MIL-STD-461A/462 NOTICE: Part 5	TEST POSITION: Return Power Line	DATE: 12/11/86
OPERATING CONDITIONS:	OPERATOR: R. Cresswell	CAL. DATE: 5/13/87
REMARKS: Wideband Measurement = 90dB		

ATT. USED +20/C ☐ BW 10KHz SCAN 30S



APPENDIX H:

CE03 TEST DATA PLOTS

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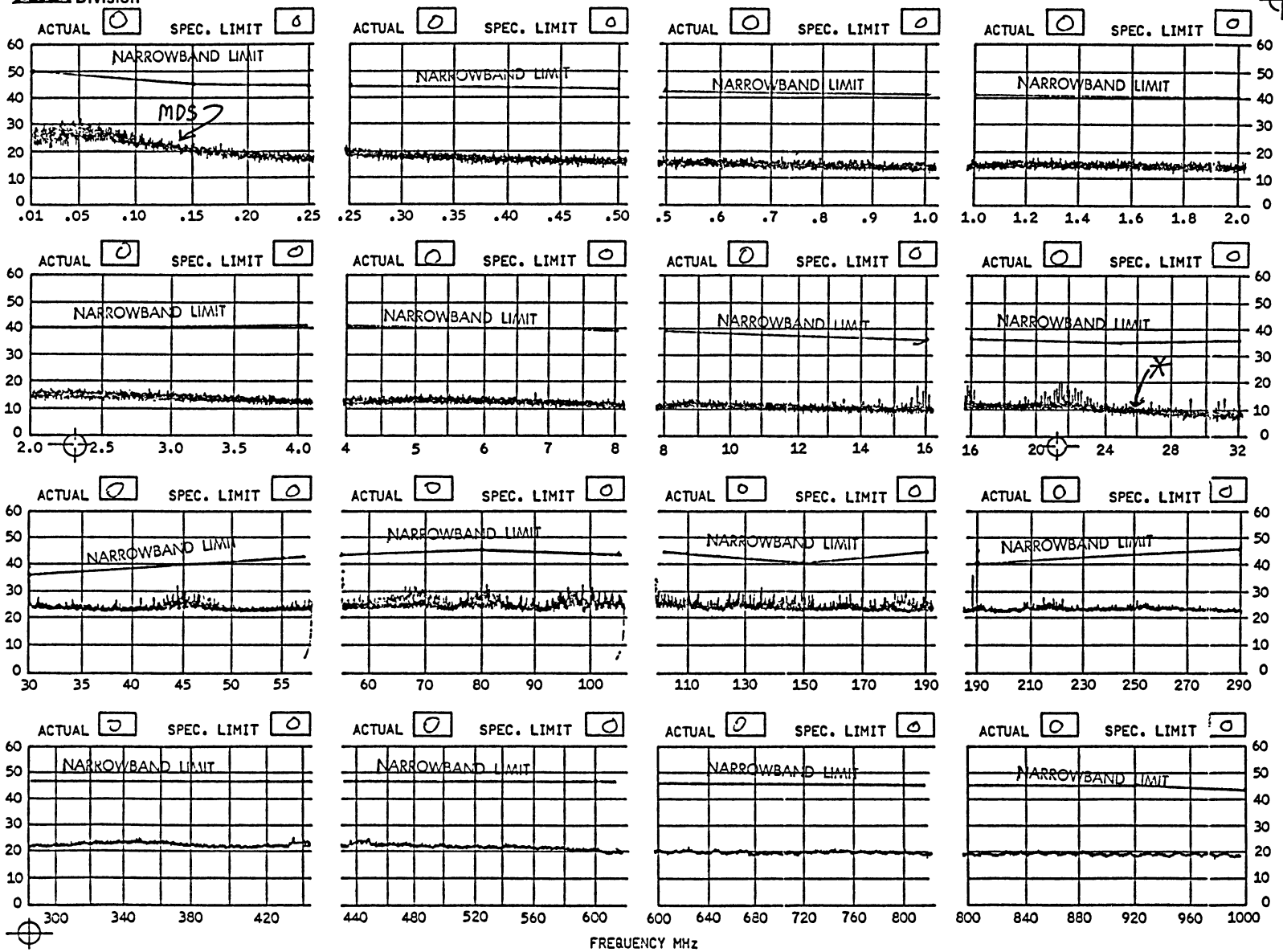
Bell Aerospace Systems Division

ATTENUATOR SETTINGS



PAGE NO. 1

TEST ORDER NO. ---

CUSTOMER ---

TEST SAMPLE 600M

PART NO. Sperry #2

SERIAL NO. —

DATE 12/11/86

SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	
RADIATED	X
BROADBAND	
NARROWBAND	X
TRANSIENT	

TEST MODE RE02

CONDUCTED BY R. Cresswell

WITNESSED BY

TEST EQUIPMENT Biltech Series 7

NM17/27 Bw = 1kHz

NM37/57 Bw = 100 kHz

CURRENT PROBE —

ANTENNA Rod, Bicon, LogCon

BANDWIDTH See Above

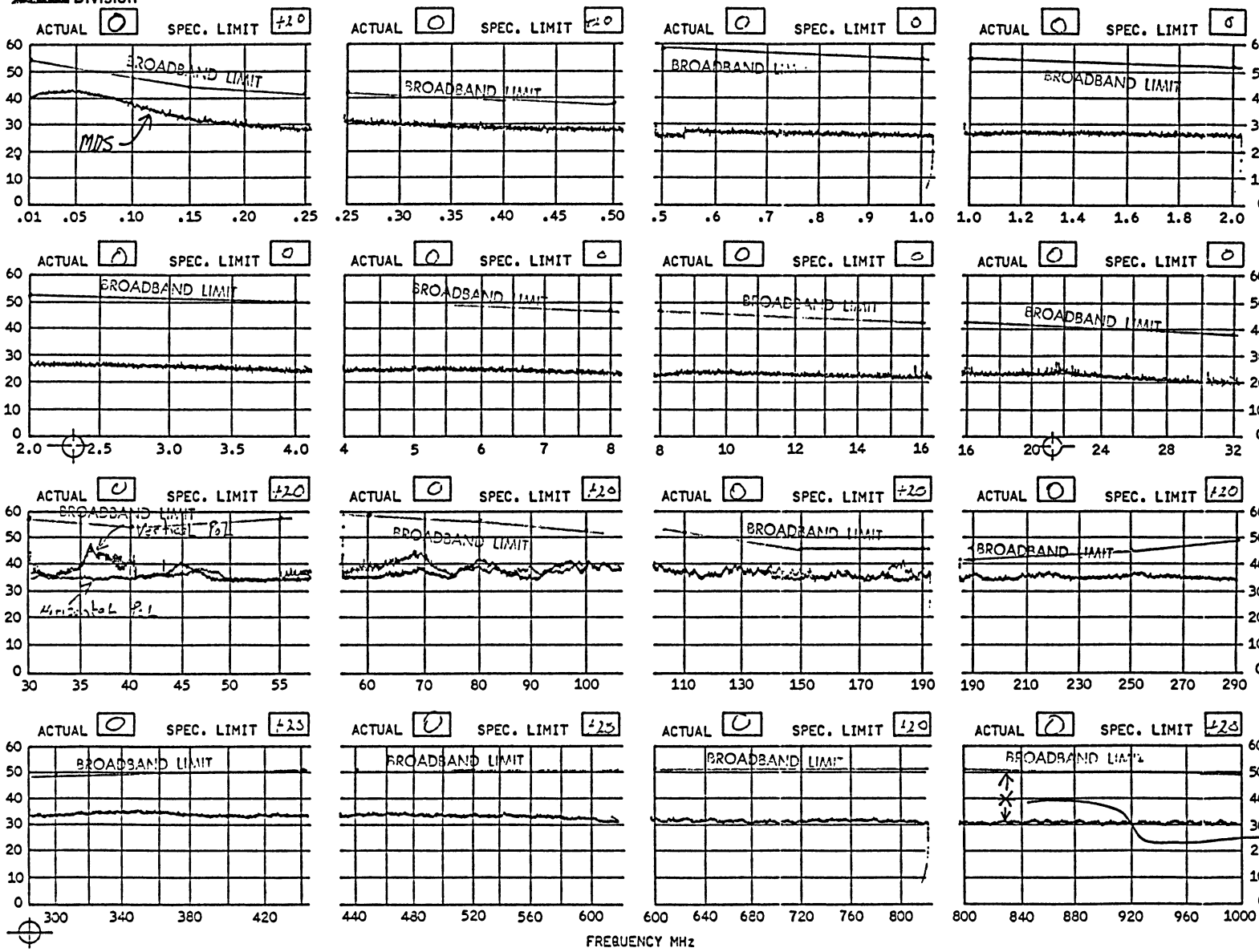
SCAN SPEED 210 S/SCAN

REMARKS LNA USED. (27 dB Gain)
Recorded levels are MDS of system, and recorded signals very closely tunable. Exc @ 25 MHz, Level = −6 dBuV/m or −113 dBm/m.

Bell Aerospace Systems Division

ATTENUATOR SETTINGS

PAGE NO. 12


ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
MDS
.01 .05 .10 .15 .20 .25
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
.25 .30 .35 .40 .45 .50
ACTUAL 0 SPEC. LIMIT 0
BROADBAND LIMIT
.5 .6 .7 .8 .9 1.0
ACTUAL 0 SPEC. LIMIT 0
BROADBAND LIMIT
1.0 1.2 1.4 1.6 1.8 2.0
ACTUAL 0 SPEC. LIMIT 0
BROADBAND LIMIT
2.0 2.5 3.0 3.5 4.0
ACTUAL 0 SPEC. LIMIT 0
BROADBAND LIMIT
4 5 6 7 8
ACTUAL 0 SPEC. LIMIT 0
BROADBAND LIMIT
8 10 12 14 16
ACTUAL 0 SPEC. LIMIT 0
BROADBAND LIMIT
16 20 24 28 32
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
Vertical Pol
Horizontal Pol
30 35 40 45 50 55
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
60 70 80 90 100
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
110 130 150 170 190
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
190 210 230 250 270 290
ACTUAL 0 SPEC. LIMIT +25
BROADBAND LIMIT
300 340 380 420
ACTUAL 0 SPEC. LIMIT +25
BROADBAND LIMIT
440 480 520 560 600
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
600 640 680 720 760 800
ACTUAL 0 SPEC. LIMIT +20
BROADBAND LIMIT
800 840 880 920 960 1000
FREQUENCY MHz

TEST ORDER NO. 1

CUSTOMER

TEST SAMPLE 600 M

PART NO. Sperry #2

SERIAL NO. –

DATE 12/11/86

SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	☐
RADIATED	☒
BROADBAND	☒
NARROWBAND	☐
TRANSIENT	☐

TEST MODE REQ2

CONDUCTED BY R. Crossell

WITNESSED BY

TEST EQUIPMENT A.I. Tech Series 7

NM17/27 Bw = 10 kHz

NM37/57 Bw = 1 MHz

CURRENT PROBE –

ANTENNA Rd. B. Con, Log Con

BANDWIDTH See Above

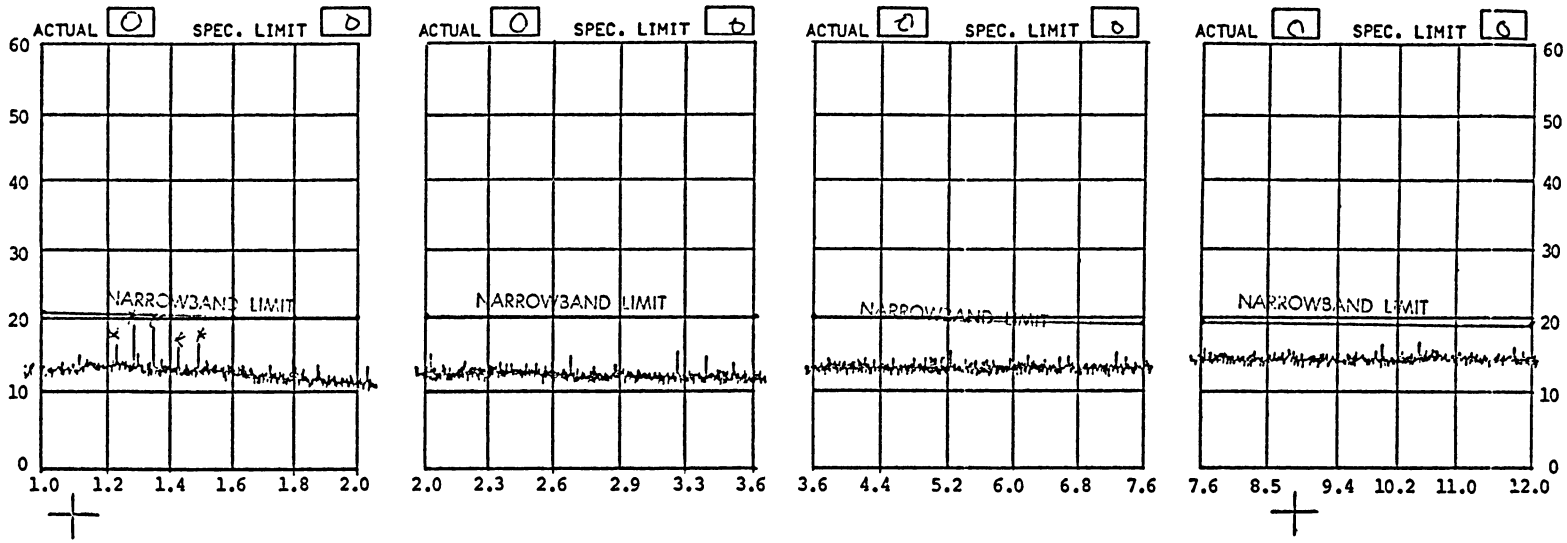
SCAN SPEED 210 S/Scan

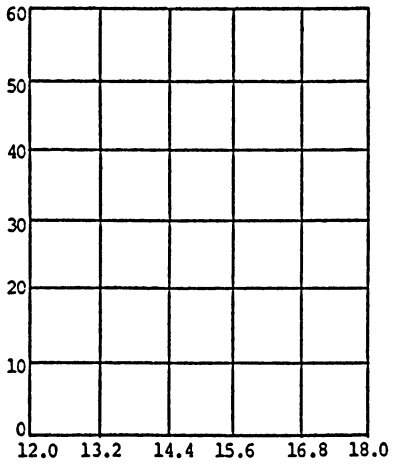
REMARKS LNA USED. (27 dB gain)

* In reality 40 dB apart From Spec

Aerospace Systems Division

ATTENUATOR SETTINGS





FREQUENCY GHz

PAGE NO. 3

ST ORDER NO.

CUSTOMER

TEST SAMPLE Lance M

PART NO. Spacecraft #2

SERIAL NO. —

DATE 12/11/86

SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	☐
RADIATED	☒
BROADBAND	☐
NARROWBAND	☒
TRANSIENT	☐

TEST MODE REOZ

CONDUCTED BY R Crozwell

WITNESSED BY

TEST EQUIPMENT Dalmo Sensor 7

NM1767

CURRENT PROBE —

ANTENNA H-cN

BANDWIDTH 100 kHz

SCAN SPEED 210 S/scan

REMARKS X NOT Repeatable

Boeing Aerospace Systems Division

ATTENUATOR SETTINGS

PAGE NO. 4

ST ORDER NO.

CUSTOMER

TEST SAMPLE 600M

PART NO. Sperry #2

SERIAL NO. —

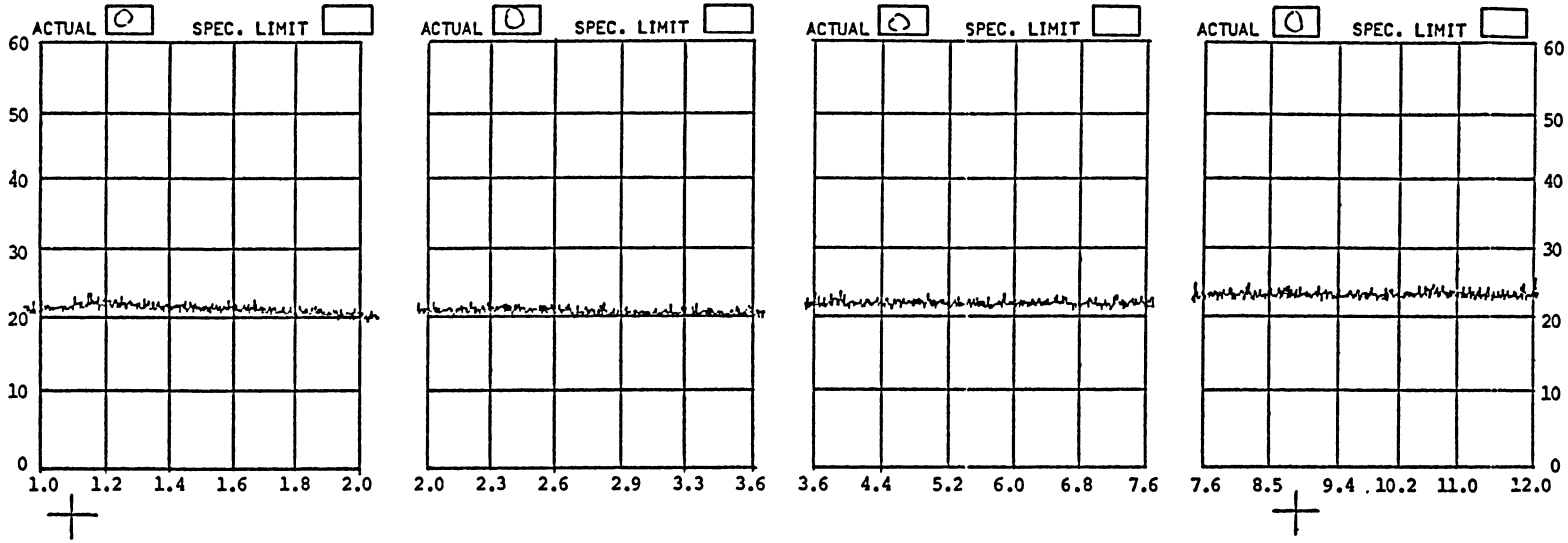
DATE 12/11/86

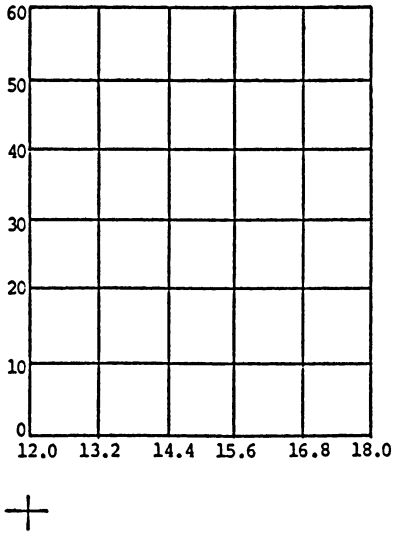
SPECIFICATION MIL-STD-461B

NOTICE Part 5

TEST METHOD

CONDUCTED	☐
RADIATED	☒
BROADBAND	☒
NARROWBAND	☐
TRANSIENT	☐





FREQUENCY GHz

TEST MODE RE02

CONDUCTED BY R. Crestwell

WITNESSED BY

TEST EQUIPMENT Alltech Series 7

NM 17727 ✓

CURRENT PROBE —

ANTENNA Hi-N

BANDWIDTH 1 MHz

SCAN SPEED 200 S/SCAN

REMARKS 1 NA NOT USED

Not Specified

APPENDIX I:

COMPOSITE MIL-STD-461B AND CE03 DATA PLOT

(To be supplied)

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